

derived and detailed numerical examples are given. Performance evaluation and design modification for Stirling engines could benefit from the findings of the study.

#### 98/03239 Prediction of mixture formation and heat-release in a turbocharged direct-injection diesel engine

Chan, S. H. and Chen, X. S. *J. Inst. Energy*, March 1998, 71, 33–46.  
In order to predict the rate of heat-release in a turbocharged direct-injection diesel engine, a multi-zone combustion model has been developed. The model considers the complete air-fuel jet mixing process and temperature-dependent reaction rates in each zone; this allows the distribution of the burning rate, local temperature and equivalence ratio to be determined both spatially and temporally. The predicted combustion pressures in the closed engine cycle are validated satisfactorily by experimental results obtained from a computer-controlled engine test-bed. The extension of the model to prediction of exhaust emissions during transient engine operation is also discussed.

#### 98/03240 Reciprocating steam engine power plants fed by woodwaste

Bidini, G. *et al. Int. J. Energy Res.*, 1998, 22, (3), 237–248.  
Small size power plants can be operated successfully with reciprocating steam engines fed by facilitated renewable energy sources like wood waste. Until now, reciprocating steam engines have only been employed in third world countries where energy is in short supply. However, it has now become attractive to developed countries because of growing environmental sensitivity. Application to a real case shows conditions for the economic feasibility of reciprocating steam engine in comparison with the heat based or other cogeneration techniques. An economic analysis is performed by the annual equivalent method and the internal rate of return method.

#### 98/03241 Reduction of emission from spark-ignition engines in USA and Europe

Svajgl, O. *Pet. Coal*, 1997, 39, (1), 37–40.  
Emissions reduction from spark-ignition engines is reviewed in this paper. The situation in the US, the cost of refinery for emissions reduction, the benefits of emissions reduction, the effects of fuel composition on emissions from spark-ignition and diesel engines, the treatment of gasoline in Europe and the Western Europe situation are the subjects covered.

#### 98/03242 Reduction of iron ore with coal by microwave heating

Zhong, S. *et al. Trans. Soc. Min., Metall., Explor.*, 1996 (Pub. 1997), 300, 174–178.  
As an alternative to conventional reduction processes, microwave heating of iron ore was investigated to solve the problem of slow heat transfer. Microwave heating and reduction tests were run on composite green balls made from coal and magnetite concentrate. Both powdered and pelletized feeds were subjected to bench-scale testing using a 15 kW microwave generator, obtaining a significant increase in the reduction rate. With 20% excess stoichiometric carbon in the mix, more than 90% reduction of the iron ore can be achieved in about 10 min at temperatures of around 1000°C. The reduction of iron ore with coal by microwave heating produces a pure, dust-free, high-Btu flue gas that can be used in related thermal operations. Depending on the purity, the reduced iron product could be fed directly to an electric arc furnace for melting. It may be necessary in some cases to remove a slag phase to eliminate excess silica and alumina.

#### 98/03243 Technical scheme and performance prediction for the gas turbine adopted in IGCC

Liu, Z. and Lin, R. *Gongcheng Rewuli Xuebao*, 1997, 18, (3), 285–287. (In Chinese)  
Adopted in integrated gasification combined cycle (IGCC), a gas turbine scheme and a two-step model to predict their performance was proposed. Example calculations of practical value and data analysis are presented.

#### 98/03244 Thermodynamics analysis of inverse cycle engine for hypersonic propulsion

Liu, X. and Zhang, S. *Gongcheng Rewuli Xuebao*, 1997, 18, (2), 145–148. (In Chinese)  
As a candidate scheme for hypersonic air-breathing propulsion, the specific thrust and specific impulse of an inverse-cycle engine were analysed using a constant specific heat method and a chemical equilibrium thermodynamic method. The performance of and inverse-cycle engine was compared with that of a ramjet engine and a turbojet with an afterburner. The effect of the temperature limit of the main combustor, the temperature limit of the front combustor, equivalence ratio, turbine expansion ratio, etc., on the performance of the inverse-cycle engine were also analysed. It was concluded that in a rich fuel mode the specific thrust performance of the inverse-cycle engine was better than that of ramjet engine, especially when the Mach number is very low (<1.5) and very high (>4.5).

#### 98/03245 The US Department of Energy—investing in clean transport

Chalk, S. G. *et al. J. Power Sources*, 1998, 71, (1/2), 26–35.  
Together with six other federal agencies and America's three largest car makers, the US Department of Energy (DOE) is jointly investing in the development of polymer electrolyte membrane (PEM) fuel cells as a clean

and efficient technology for automotive propulsion under the Partnership for a New Generation of Vehicles (PNGV). The successful development of PEM fuel cells to meet automotive requirements is expected to extend beyond the PNGV's 2004 timeframe for achieving 80 miles per gallon in production prototypes. Given the extraordinary promise of substantial benefits to the nation in energy, environmental and economic aspects from fuel cells and other long-term technologies, the PNGV partners will continue to invest in these technologies beyond 2004. This paper describes the status of the PNGV program and the key role and technical accomplishments of the DOE Transportation Fuel Cells Programme.

## 11 PROCESS HEATING, POWER AND INCINERATION

### Energy Applications in Industry

#### 98/03246 Agent for improving transportation of powdered coal in furnace

Ono, R. *et al. Jpn. Kokai Tokkyo Koho JP 09,256,016* [97,256,016] (Cl. C21B5/00), 30 Sep 1997, Appl. 96/68,514, 25 Mar 1996, 10 pp. (In Japanese)  
One or more are selected from  $C_{\leq 10}$  alcohol and  $C_{\leq 10}$  amine in the agent, which is applied on coal having hard groove grindability index (HGI)  $\geq 30$ . The fine powdered coal modified with the agent is dry at the inlet for blowing metallurgical or burning furnace. A powder prepared by pulverizing coal of HGI  $\geq 30$  and adding the agent on the surface and operation of furnace by using the coal is also described.

#### 98/03247 Blast furnace process analysis using a mathematical thermochemical model

Carneiro, R. T. S. and de Paiva Giudice, F. D. *Congr. Anu. Assoc. Bras. Metal. Mater.*, 1996, 51, (1), 309–324. (In Portuguese)  
Based on the Rist Diagram's theory, a mathematical thermochemical model was developed at USIMINAS Research and Development Centre in order to provide the blast furnace operator with a correct evaluation of process instability. It consists of a mass and heat balance applied to the bottom segment and to the entire furnace and evaluate the main thermochemical parameters which help to analyse and control the process. During some instability periods of No. 3 EF of USIMINAS works, a practical example of the model application is presented. The results confirmed the suitability of the method for correcting operation instabilities indicating the measures to be taken to assure an optimized BF practice.

#### 98/03248 Characterization of pulverized and granular coal injection chars

MacPhee, J. A. *et al. DGMK Tagungsber.*, 1997, 9703. (Proceedings ICCS '97, Volume 2), 1311–1314.  
A pilot-scale injection unit was used to examine a series of coals, ranging from sub-bituminous to low-volatile bituminous. The char reactivities were measured at conditions similar to those that would be encountered in the blast furnace raceway for both pulverized and granular chars. All the chars tested were more reactive than tuyere coke, indicating that inside the blast furnace raceway,  $O_2$  preferentially reacts with char over tuyere coke. The injection of coal is thus beneficial in reducing coke consumption and increasing the productivity and performance of the blast furnace. Microscopic examination of the original coals and the GCI chars gave clear distinctions in maceral count in the partial transformation of coal to char during the high temperature process.

#### 98/03249 Combustion and gasification reaction behavior of waste plastic in a blast furnace

Yamaguchi, K. *et al. Tetsu to Hagane*, 1997, 83, (9), 545–550. (In Japanese)  
Two kinds of model experiment were used to investigate the behaviours of plastic pyrolysis, combustion and gasification reaction in order to establish the plastic injection technology in the blast furnace. The model experiments were: (1) vertical tower type reactor called the combustion model and (2) the blast furnace type reactor called the hot model. The combustion of plastic does not occur in the blast having the temperature of 1250°C and the  $O_2$  enrichment of 0% in the blowpipe and tuyere, but it starts in the air over the temperature of 1550°C. However, the  $CO_2$  gasification does not occur at this temperature in the combustion model. The split of plastic occurs in the atmosphere over the temperature of 2000°C in the raceway from 1000–2000  $\mu m$  to 200  $\mu m$ . The split plastic is burnt in the raceway, the unburnt plastic is consumed and accumulated in the hot model and it does not flow out of the top. The entering of plastic contained fines into the dead-man can be suppressed by injecting the plastic directly into the raceway through the tuyere or by keeping the distance of the lance tip from the tuyere nose as short as possible in case of the injection through the side of blowpipe.